REMARKS

In view of the above amendments and the following remarks, reconsideration of the outstanding office action is respectfully requested.

The Objection to the Specification Under 35 U.S.C 132

The specification was objected to under 35 U.S.C. 132 since it was said to introduce new matter into the disclosure of the invention. Applicants submit that the new paragraph 0048.1 containing the added material has been canceled. Additionally, as requested by the Examiner, the added statement concerning removably mounted reflective elements in paragraph 0049 has been removed and the paragraph has been reverted to it original content. Therefore, Applicants request reconsideration and withdrawal of this objection since the amended specification does not contain any new subject matter.

The Objection to the Claims Under 37 CFR 1.75(c)

Claim 26 was objected to under 37 CFR 1.75(c) since it was said to be of improper dependent form and failing to further limit the subject matter of a previous claim. This objection is respectfully traversed. Applicants submit that dependent claim 26 has been rewritten to further limit the subject matter of parent claim 19. Particularly, claim 26, as currently amended, recites additional planar reflectors extending parallel to curved reflective surfaces of claim 19 and having the same basic orientation.

The objection of claim 23 as lacking antecedent basis is respectfully traversed. Applicants have amended claim 23 to correct the typing error and refer to claim 22 reciting "photovoltaic cell" instead of referring to claim 20.

Claim Rejection Under 35 USC § 112

The rejection of claim 29 under 35 U.S.C. §112, as failing to comply with the written description requirement, is respectfully traversed.

Claim 29 has been rewritten as new claims 37 and 38 to more particularly point out and distinctly claim the subject matter of the invention in a patentable manner. The limitation of rejected claim 29 directed to removably mounted reflective surfaces has been removed.

New claim 37 recites "support means" supporting reflective surfaces so that they can be individually adjusted by means of rotating around their longitudinal axes and moving relatively to one another. This subject matter is supported by the specification of this invention as originally filed.

In particular, Fig. 1 shows reflective elements with mirrored (reflective) surfaces and a frame comprising bands of metal, plastic, wood or other material extending transversely of the longitudinal axes of the reflective elements at their ends (see also p. 3, paragraph 0038). As paragraph 0038 further teaches, the reflective elements may be secured to the bands by individual brackets or slots (shown in Fig. 1) to facilitate the replacement and/or adjustment of individual reflective elements. Furthermore, the specification recites positioning the reflective elements so that they can be rotated around their longitudinal axes and/or moved relatively to each other and the receiver (see, e.g., p. 3, paragraph 0045) thus redirecting the convergent beams to preselected, individual converging directions. This can be used, for example, for the adaptation of the concentrator to a specific shape of the receiver or for tracking the energy source movement.

New claim 38 recites arranging "said reflective surfaces" in two or more arrays that can be individually tilted, rotated, and positioned differently relatively to each other and "said energy receiving means". Fig. 1 shows two symmetrically disposed arrays assembled on a common frame but tilted at an angle relatively to each other and the receiver target plane, as opposed to an alternative arrangement shown in Fig. 6 and comprising a single array (asymmetric design). Fig. 5 shows two independently oriented arrays of reflectors halfway encircling a tubular absorber extending parallel to the reflectors' longitudinal axes.

Thus, Applicants submit that the subject matter recited in new dependent claims 37 and 38 and incorporating in combination all subject matter of claims 19 and 20, respectively, is not found in any of prior art references and, thus, makes them independently novel and patentable.

Claim Rejections – 35 USC § 102

The rejection of claims 19-25, 27, 28, 30-32 and 34-36 under 35 U.S.C. §102(b), as being anticipated by York 4347834 is respectfully traversed.

Independent claim 19 has been amended to more particularly point out and distinctly claim the subject matter of the invention in a patentable manner. Applicants request reconsideration of this rejection for the following reasons:

York shows a rear-focus parabolic collector formed as an array of concentrically nested **annular** conic frusta symmetrically disposed about a focal axis passing through their geometric centers (see, e.g., Fig. 1, col. 2, l. 54-57, and col. 5, l. 3-8). Applicants show an array of "**elongated** reflective surfaces" having "concave **transversal** profiles", "front **longitudinal** ends" and "opposing rear **longitudinal** ends". The same applies to dependent claims 20-28 and 30-38.

York does not show elongated reflective surfaces having front and rear longitudinal ends. He shows the collector representing a continuous, uninterrupted annular surface (col. 4, l. 5) thus teaching away from using an array of non-annular, individually aligned, elongated reflective surfaces.

Each of York's cylindrically shaped reflective frusta is defined by a singular and unique parabola having an upper rim and a lower rim and focusing the incident radiation to a focal point. The collector composed by an array of these frusta being concentrically nested around a common focal axis produces a point focal image on a concentrator-absorber which is fixed in relation to the collector (col. 2, l. 48-51). It will be appreciated by those skilled in the art that all concentrated energy beams reflected from conic frusta of this reference will be aligned along a single direction coinciding with the common focal axis. In the contrary, the elongated reflective surfaces of the present invention reflect the incident radiation to a plurality of **preselected** converging directions which is completely foreign to York.

The present invention shows reflective surfaces which can be **individually positioned and oriented** at different angles relatively to each other. Furthermore, the surfaces can be **independently** rotated around their respective longitudinal axes so that the directions of corresponding energy beams reflected from the surfaces will change. This can be useful, for example, for spreading the linear focal spot over a larger area and providing a more uniform receiver illumination. Clearly, York does not teach this feature since his continuous annular surfaces create a fixed focal point defined by unique parabolic profiles of the surfaces.

Yet further, York's collector employs annular surfaces circumscribing the noncollecting central portion. As a part of collector aperture of this reference is noncollecting, the corresponding portion of incident energy is lost and energy collection efficiency is reduced. The present invention employs linear trough-like reflectors which allow to eliminate the noncollecting area, see for example an asymmetric design shown in Fig. 6, and capture all incident radiation thus improving energy collection.

The last O.A. stated (p. 4, last paragraph) that York shows a collection apparatus including an array of spaced apart concave reflectors (12) with inclined ends and which are positioned to reflect radiation by means of a single reflection to elongated energy receiving means.

Applicants respectfully submit that claim 19 (as amended) distinguishes over York under Section 102 because York does not show "elongated reflective surfaces" having front and rear ***longitudinal*** ends positioned to reflect the incident energy to "a plurality of preselected converging directions" and form a linear focus. On the contrary, each of York's reflectors has closed-end circular ends produced by the revolution of a unique parabolic profile around a common focal axis.

York does not show the collection of concentrated energy reflected from conical frusta on an "elongated energy receiver means". He merely describes the transfer or conversion of the energy by methods well known in the art. Particularly, York refers to the absorber immersed in an absorber tube which is filled with a heat-transfer medium (col. 6, l. 15). However, this reference does not teach illuminating a tubular absorber with a linear focus extending along the absorber's longitudinal axis. Applicants show elongated reflectors forming a linear focus on an elongated receiver which provides the energy absorption and conversion in a most favorable manner. It will be appreciated by a skilled artisan that forming a linear focus with the York's point-focusing collector is impossible. Thus, the York's reflectors do not enable the most appropriate illumination of a linear receiver such as a fluid-carrying tube or arranged in line photovoltaic cells shown in the present invention (see, e.g., Figs 1 and 5).

The last O.A. stated (p. 5, first paragraph) that York's device satisfies the claimed conditions for angles α and β, referring to Fig. 2 in this reference. It also stated that the reflectors are arranged so as to minimize screening and constitute sections of curve which satisfy the types set forth in claims 31,32,34 and 35.

Applicants respectfully submit that concentrically nested, confocal parabolic reflectors such as those which partial cross-section is shown in York (fig. 2) are well known in the art. However, despite the axial cross-section of these previous art ring-like reflectors may look similarly to the transversal cross-section of an array of slat-like surfaces, they operate differently than the plurality of elongated concave surfaces shown in the present invention since they cannot produce a linear focus and cannot be positioned to create a plurality of spaced apart or partially overlapping focal zones.

Referring to the axle/tracking system shown in fig. 1 of York, Applicants submit that "axle support means" recited in claim 36 constitutes a further limitation of independent claim 19 which makes claim 36 a fortiori patentable over York. By adding an axle support, Applicants improve the collection efficiency of the apparatus for collecting and converting radiant energy since it allows for capturing more radiation from a moving source such as the sun.

Thus, for the above reasons, applicants request reconsideration of the rejection of claims 19-25, 27, 28, 30-32 and 34-36 under 35 U.S.C. 102.

Claim Rejections – 35 USC § 103

The rejection of claims 19-36 as being unpatentable under 35 U.S.C. §103(a) over Popovich et al 4337759 in view of York is respectfully traversed. The rejection of claims 26, 29 and 33 as being unpatentable under 35 U.S.C. §103(a) over York is also traversed.

Applicants submit that the novel physical features of claim 19, as amended, are unobvious and hence patentable under §103 since they produce new and unexpected results over York and Popovich, or any combination thereof.

These new and unexpected results are the ability of applicant's system to collect the incident radiant energy with a plurality of elongated, concave reflective surfaces and focus this energy onto to a linear receiver by means of a single reflection and in a most favorable manner. This, in turn, results in a more efficient energy conversion and improved system utility.

The last O.A. stated that Popovich shows a collection apparatus including an array of spaced apart reflectors with inclined ends and which are positioned to reflect radiation by means of a single reflection to elongated energy receiving means.

Applicants respectfully submit that Popovich shows a radiant energy concentrator based on the passage of radiant energy through a transparent body employing refractive facets which have an entry face to receive impingement of the radiation and an exit face to pass energy to the exterior of the body. These facets redirect the energy by means of total internal reflection from an internal reflection face disposed on the path of energy between the entry face and the exit face.

It will be appreciated by those skilled in the art that the radiant energy passing through a transparent body such as that shown in Popovich will incur at least two reflections at the interfaces between the body and the surrounding medium. Since Popovich additionally utilizes the total internal reflection, the radiant energy passing through Popovich's device will incur a triple reflection: an external reflection from entry face 54, the total internal reflection from face 51, and an internal reflection from exit face 52 (see Fig. 4b in Popovich).

As a matter of optics, the reflection from each of the refractive body interfaces in Popovich will result in reflective losses. The reflection of the radiation from a surface of the refractive body depends upon the indices of refraction of the body and the interfacing media, as well as upon the angle of incidence and upon the plane of polarization of the light (see, e.g., Sec 25.2 in Jenkins, F A and White, H E , Fundamentals of Optics, 4E, McGraw-Hill, 1976).

For the purpose of the estimation of minimum reflection losses at the interfaces of a transparent body, the reflectivity at the normal incidence can be calculated. The normal incidence reflectivity R for the interface of two media with respective refraction indices n_1 and n_2 is defined by the general expression derivable from Fresnel's equations:

$$R = \left[\frac{n_2 - n_1}{n_2 + n_1}\right]^2$$

Therefore, the amount of light transmitted through a refractive transparent medium such as Flint glass with the refraction index of 1.65, assuming the other media being air which refraction index is about 1.00029 and disregarding the transmittance losses, can be calculated as follows:

The amount of light reflected externally from first surface: 0.060 which is 6%.

Transmitted into refractive medium: 94%

Reflected internally from second surface: 5.6%

Transmitted through medium: 88.3%.

Applicants' apparatus utilizes individual reflective surfaces with the specular reflectivity offering much higher reflection efficiency. For example, a silvered mirror reflects over 95% of incident energy in the visual spectrum resulting in a superior energy collection compared to Popovich's device.

Additionally, the refractive system shown in Popovich, as any other refractive system, will exhibit dispersion for the incident radiation (especially for non-point sources of radiant energy, e.g., the Sun) impinging on the entry face and exiting from the exit face in accordance with the Snell's law. As the refractive index depends on the radiation wavelength, the dispersion and the total internal reflection angles also depend on the wavelength thus reducing the energy focusing ability. Furthermore, Popovich's device will inherently exhibit transmittance losses connected to the passage of the energy through the refractive substance. The Applicants' apparatus utilizes specular reflectivity which eliminates these limitations of refractors and is therefore a more efficient energy collection system.

Yet further, Applicants submit that Popovich's device has a limitation on the incident angles which should be greater than the Brewster's angle (see the corresponding discussion in Popovich, col. 2, l. 47-50) which, in turn, limits the collector aperture. The Applicant's system does not have this limitation since the specularly reflective surfaces can be positioned at any angle with respect to the source of incident energy without impairing the reflection ability.

Thus, applicants submit that Popovich teaches away from using a single reflection from a reflective surface and shows a device which shows significant losses compared to the Applicants' system which does not have fundamental limitations inherent to refractive optics. The Applicants' system is therefore vastly superior to Popovich's device.

The Popovich's system is also impractical since it cannot operate without the single solid body of a refractive material which is mandatory for creating the condition of the total internal reflection at certain angles of incidence. The refractive material adds weight and cost to the system. Applicants'

system employs spaced apart individual reflective surfaces with no refractive medium between them and, therefore, improves the utility of the system.

The present invention also shows a plurality of refraction-free reflectors which can be positioned differently, moved and/or rotated relatively to each other. This is entirely foreign to Popovich showing a single refractive body where the totally internally reflective faces have predefined positions which cannot be changed.

The Examiner agreed in the last O.A. (p.6, l. 6) that Popovich does not teach the reflectors to have concave profiles. However, it was stated that such surfaces are common in solar collection devices and an example is shown in York. The O.A. also stated that it would have been obvious to the ordinarily skilled artisan at the time of invention to use concave surfaces in Popovich's device in order to increase the amount of radiation convergence upon the energy receiving means.

Applicants respectfully submit that there are no provisions for the use of concave reflective surfaces to redirect the incident radiation to a linear receiver by means of a single reflection in Popovich. Popovich merely shows internal faces in a transparent refractive body which can operate only when certain conditions for the radiation passing through the body are met. These conditions include the required difference in refraction indices of the transparent body and the external medium and specific angles of incidence limited to be greater than the Brewster's angle. In turn, this limits the redirective bend angles to be less than 90°. In the example taught in Popovich (col.2, l. 47-50), the bend angle is limited to 96° for acrylic.

Moreover, if concave profiles were used for the totally internally reflective faces in Popovich, the reflected rays would be crossing the exit face at different angles thus resulting in additional dispersion and reducing the collection efficiency. Additionally, the incident energy will strike the curved reflecting face at different incidence angles which may become less than the total internal reflection angle for some portions of the face resulting in the loss of reflectivity. The Applicants' system utilizes specularly reflective surfaces which reflect the incident energy at any angle of incidence and, as a matter of optics, allow the bend angles to be up to 180°.

As it was stated above, the systems of York and Popovich do not show elongated reflective surfaces having concave profiles and reflecting the incident energy into a plurality of converging directions.

York collects the incident energy using a rear-focus parabolic collector formed as an array of concentrically nested annular conic frusta symmetrically disposed about a focal axis passing through their geometric centers and focusing along the same focal axis. Popovich utilizes a solid refractive body having an entry face, the total internal reflection face, and an exit face.

The York's device has a part of collector aperture which is noncollecting and which results in the loss of the corresponding portion of incident energy. As it was discussed above, a portion of the incident energy is also lost in the Popovich's device due to the reflection losses at the transparent body interfaces and limited transparent body transmissivity which cannot be 100%. The present invention employs linear trough-like reflectors focusing the incident radiation by means of a single reflection and eliminates the non-collecting area of York and the reflective and refractive losses of Popovich.

Thus, the reason given in the last O.A. regarding the combination of York's concave surfaces in Popovich's device in order to increase the amount of radiation convergence upon the energy receiving means is not sufficient to support the proposed combination. Even if Popovich and York were to be combined in the manner proposed, the proposed combination would not show all the novel physical features of claim 19 and advantages of this invention.

Applicant's system is vastly superior to that of either York or Popovich, or any possible combination thereof. The novel features of Applicants' system which effect the stated above differences are clearly recited in claim 19. The novel physical features of claim 19 produce new and unexpected results and hence are unobvious and patentable over York and Popovich under §103.

The Dependent Claims are a Fortiori Patentable over York and Popovich

Dependent claims 20-28 and 30-38 incorporate all subject matter of claim 19 and additional subject matter which makes them a fortiori and independently patentable over these references.

Particularly, claim 20 recites an elongated energy receiving means disposed so that the convergent energy beams reflected from adjacent reflective surfaces at least partially superimpose on it. York does not show elongated energy receiving means disposed in a manner of optimal utilization of the concentrate radiation, and Popovich does not show convergent beams since his totally internally reflective faces are planar.

Claims 21-24 add further limitations to the novel features of claims 19 and 20 regarding the position of energy receiver and using different types of the receiver and thus, in combination, produce novel and unexpected results.

Claim 25 recites the mechanical separation of the energy receiver from the plurality of reflective surfaces. Neither York nor Popovich do this.

Claim 26, as amended, further adds one or more elongated planar reflectors extending parallel to the concave reflective surfaces of claim 19 and having the same basic orientation. Neither of the prior art references show such reflectors in combination with an array of elongated concave reflective surfaces focusing the incident radiation through spaced between the adjacent surfaces and using a single reflection.

Claim 27 recites a further limitation on the slopes of elongated reflectors so that the angles of incidence of radiant energy have values more than 45° and 90°. Neither York nor Popovich do this in combination with elongated concave reflectors.

Claim 28 recites additional limitations for positioning the elongated concave reflectors of claim 19 such as rotation relatively to the other surfaces. It will be appreciated that the rotation of elongated reflectors will change the orientations of tranversal profiles of the reflectors. The internally reflective faces of Popovich's cannot be positioned differently since they belong to a single solid body. The profiles of York's device also cannot be rotated relatively to one another since they form conical frusta symmetrically disposed about a common focal axis and defined by a singular and unique parabola, and which is inclined in and upwardly and outwardly slanting direction toward the Sun.

Claim 30 recites specific designing and positioning elongated reflectors to minimize screening and shadowing on other reflective surfaces. Neither York nor Popovich do this with respect to elongated concave reflective surfaces.

Claims 31 to 35 recite specific profiles of reflective surfaces including conical sections, a polynomial function, a parametric curve, a spline, and a set of conjugated lines being straight, parabolic, circular, elliptical or hyperbolic segments. Applicant submit that while these profiles are well know in the art, no other reference shows them in combination with a plurality of elongated concave profiles reflecting

the incident energy to a plurality of converging directions through spaces between adjacent surfaces and by means of a single reflection. Neither York nor Popovich show elongated concave profiles for reflective surfaces clearly recited in independent claim 19. As the limitations of claims 31 to 35 produce new and unexpected results being, for example, the increase in energy collection efficiency or the use of less expensive circular or planar profiles, the features recited in these claims, in combination with novel and unobvious features of claim 19 are also novel and unobvious.

Claim 36 recites an axle support means for positioning the array of reflective surfaces according to the movement of radiant energy source. Accordingly, while the energy source trackers are known in the art, neither previous art reference including York and Popovich show them in combination with the novel features of independent claim 19.

New dependent claim 37 recites a support means arranged so that the reflective surfaces can be individually adjusted by rotating around their respective longitudinal axis.

New dependent claim 38 recites arranging the reflective surfaces in two or more arrays that can be individually tilted, rotated, and positioned differently relatively to each other and the energy receiver.

The last O.A. stated (p.7, l.6) regarding claims 26 and 33 that, although not taught by the reference, it would have been obvious at the time of invention to make the reflectors of York with either a flat or circular profiles.

Applicants submit that York does not show elongated reflective surfaces taught in the present invention and creating a liner focal area but merely shows concentrically nested conical frusta creating a point focus. Therefore, making the reflectors of York with either flat or circular profiles will not result in the collection of incident radiation into a linear focal area.

The last O. A. stated, regarding claim 29, that, although not taught by York, removably mounted reflectors are well known in the art and that it would have been obvious to support the reflectors with such a mount in order to allow for adjustment and/or replacement of the individual reflectors. Applicants respectfully submit that, as stated above, claim 29 has been canceled and replaced with new dependent claims 37 and 38 to more distinctly claim the subject matter of the present invention and define patentably over the prior art.

Accordingly, Applicants submit that the dependent claims are a fortiori patentable and should be allowed.

Conclusion

In view of all the foregoing reasons, Applicants respectfully submit that the claims are now in the proper form and that the claims all define patentably over the prior art. Therefore, Applicants submit that this application is now in condition for allowance, and such allowance is earnestly solicited.

Request for Constructive Assistance (MPEP § 2173.02 and § 707.07j):

If the Examiner finds that patentable material is disclosed in this application but the application is not believed to be in full condition for allowance, applicants respectfully requests Examiner's constructive assistance and suggestions in order to place this application in allowable condition without the need of further proceedings.

Respectfully submitted,

Sergiy Vasylyev Viktor Vasylyev
-------------- Applicants Pro Se ------------------

10027 East Taron Dr.
Elk Grove, California, 95758
Tel. (916) 714-4917; Fax (530) 686-9935

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Date June 1, 2004 , Signature
Sergiy Vasylyev, Applicant